RECEIVED
CENTRAL FAX CENTER
DEC 1 3 2004

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

In re Application of: Nikoonahad et al.	§	Group Art Unit: 2863 Examiner: Washburn, D.
Serial No. 10/670,183	§	Atty. Dkt. No. 5589-02326/P688-04C
Filed: September 24, 2003	§	
For: METHODS AND SYSTEMS FOR DETERMINING A CRITICAL DIMENSION AND A THIN FILM CHARACTERISTIC OF A SPECIMEN	§	

I hereby certify that this correspondence is being transmitted via facsimile or deposited with the U.S. Postal Service with sufficient postage as First Class Mail in an envelope addressed to: Mail Stop Appeal Brief-Patents, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450, on the date indicated below:

12/13/2004 Pamela Gerik
Date Pamela Gerik

APPEAL BRIEF

Mail Stop Appeal Brief-Patents
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir/Madam:

Further to the Notice of Appeal faxed October 14, 2004 and received in the Patent Office on October 14, 2004, Appellant presents this Appeal Brief. The Notice of Appeal was filed following mailing of a Final Office Action on August 24, 2004. Appellant hereby appeals to the Board of Patent Appeals and Interferences from a final rejection of claims 6633-6651 in the Final Office Action mailed August 24, 2004, and respectfully requests that this appeal be considered by the Board.

I. REAL PARTY IN INTEREST

The subject application is owned by KLA-Tencor, Inc., a corporation having a place of business at 160 Rio Robles, San Jose, California 95134, as evidenced by the assignment recorded at reel 014550, frame 0455.

II. RELATED APPEALS AND INTERFERENCES

No other appeals or interferences are known which would directly affect or be directly affected by or have a bearing on the Board's decision in this appeal.

III. STATUS OF CLAIMS

Claims 1-6632 were originally filed in the present application. Claims 2-6632 were cancelled in a Preliminary Amendment filed September 24, 2003. Claims 1-6632 were canceled in a Supplemental Amendment filed January 14, 2004. Claims 6633-6652 were added in the Supplemental Amendment. Cancellation of claims 1-6632 was confirmed in a Second Supplemental Amendment filed March 30, 2004. Claim 6652 was deemed allowable, but objected to for being dependent on a rejected base claim. Claims 6633-6651 stand finally rejected under 35 U.S.C. § 102, and are the subject of this appeal. A copy of claims 6633-6652, as on appeal (incorporating entered amendments), is included in the Appendix hereto.

IV. STATUS OF AMENDMENTS

No amendments to the claims have been filed subsequent to their final rejection. The Appendix hereto therefore reflects the current state of the claims.

V. SUMMARY OF THE INVENTION

Appellant's claimed invention relates to a system configured to determine at least two properties of a specimen. (Specification -- page 147, line 15 - page 148, line 3). The system includes a spectroscopic ellipsometer (238, Fig. 23) configured to generate one or more output signals during measurement of the specimen. (Specification -- page 139, line 22 - page 142, line 13). The system also includes a processor (270) coupled to the spectroscopic ellipsometer. The processor is configured to determine a critical dimension and a thin film characteristic of the specimen from the one or more output signals. (Specification -- page 98, line 19 - page 103, line 13, page 106, lines 11-13, page 188, line 1 - page 190, line 11, page 255, lines 19-25).

In one embodiment, the system is further configured as a stand-alone device (158, Fig. 14). (Specification -- page 120, lines 20-21, page 251, lines 5-11). In an alternative embodiment, the system is integrated into a process tool (240, Fig. 23). (Specification -- page 184, line 19 - page 185, line 10).

In some embodiments, the spectroscopic ellipsometer is configured to illuminate the specimen at an oblique angle of incidence (Fig. 23). In another embodiment, the spectroscopic ellipsometer is configured to illuminate the specimen at an oblique angle of incidence with a light beam that includes visible and ultraviolet light. (Specification -- page 257, lines 14-21). In a different embodiment, the spectroscopic ellipsometer (98, Figs. 11a and 11b) is configured to illuminate the specimen at a normal angle of incidence. (Specification -- page 79, lines 5-25). In one such embodiment, the spectroscopic ellipsometer is configured to illuminate the specimen at a normal angle of incidence with linearly polarized light. In another such embodiment, the spectroscopic ellipsometer is configured to illuminate the specimen at a normal angle of incidence with polarized light. (Specification -- page 79, lines 2-5). In a further embodiment, the spectroscopic ellipsometer is configured to illuminate the specimen at a normal angle of incidence with polarized, visible light. (Specification -- page 67, line 23 - page 68, line 3, page 77, lines 4-6, page 255, lines 14-17). In some embodiments, the spectroscopic ellipsometer is

configured to focus light to a small spot on the specimen. (Specification -- page 258, lines 16-27).

In one embodiment, the processor is configured to use the thin film characteristic to determine the critical dimension. (Specification -- page 77, line 23 - page 78, line 12). In some embodiments, the system is coupled to a stand-alone metrology or inspection system. The systems are configured such that signals may be sent between the systems. (Specification -- page 267, line 19 - page 268, line 2).

In one embodiment, the thin film characteristic includes optical properties of one or more layers on the specimen. (Specification -- page 140, line 17 - page 142, line 13). In another embodiment, the critical dimension includes a lateral dimension of a feature on the specimen defined in a direction substantially parallel to an upper surface of the specimen, a lateral dimension of the feature defined in a direction substantially perpendicular to the upper surface of the specimen, or a sidewall angle of the feature. (Specification -- page 74, line 10 - page 75, line 9).

In one embodiment, the specimen (10, Fig. 1) includes a wafer. (Specification -- page 63, lines 6-12). In another embodiment, the specimen includes a substrate suitable for fabrication of a reticle. (Specification -- page 63, lines 12-14).

Appellant's claimed invention also relates to a system (32, Fig. 13) configured to determine at least two properties of a wafer (10, Fig. 1). The system includes a spectroscopic ellipsometer configured to generate one or more output signals during measurement of the wafer. The spectroscopic ellipsometer is integrated into a lithography track (130, Fig. 13). The system also includes a processor coupled to the spectroscopic ellipsometer. The processor is configured to determine a critical dimension and a thin film characteristic of the wafer from the one or more output signals. (Specification -- page 98, line 19 - page 103, line 3, page 255, line 17 - page 257, line 2).

In one embodiment, the spectroscopic ellipsometer is configured to illuminate the specimen at an oblique angle of incidence with a light beam that includes visible and ultraviolet light. (Specification -- page 257, lines 14-21). In another embodiment, the spectroscopic ellipsometer is configured to illuminate the specimen at a normal angle of incidence with polarized, visible light. (Specification -- page 67, line 23 - page 68, line 3, page 77, lines 4-6, page 79, lines 2-5, page 255, lines 14-17). In some embodiments, the system also includes a controller computer configured to control a temperature within the track. (Specification – page 257, lines 4-12).

VI. ISSUES

1. Whether claims 6633 and 6635-6651 are unpatentable under 35 U.S.C. § 102(b) as being anticipated by U.S. Patent No. 5,900,939 to Aspnes et al. (hereinafter "Aspnes").

2. Whether claim 6634 is unpatentable under 35 U.S.C. § 102(e) as being anticipated by U.S. Patent No. 6,563,586 to Stanke et al. (hereinafter "Stanke").

VII. GROUPING OF CLAIMS

Claims 6633, 6636-6637, 6642, and 6645-6647 (Group I) stand or fall together.
Claim 6634 (Group II) stands or falls alone.
Claims 6635 and 6649-6650 (Group III) stand or fall together.
Claims 6638-6641 (Group IV) stand or fall together.
Claim 6643 (Group V) stands or falls alone.
Claim 6644 (Group VI) stands or falls alone.
Claim 6648 (Group VII) stands or falls alone.
Claim 6651 (Group VIII) stands or falls alone.

The reasons why the eight groups of claims are believed to be separately patentable are explained below in the appropriate parts of the Argument.

VIII. ARGUMENT

Fabrication of semiconductor devices such as logic and memory devices typically includes a number of processes that are used to form various features and multiple levels or layers of semiconductor devices on a surface of a semiconductor wafer or another appropriate substrate. After processing is complete, the semiconductor wafer is separated into individual semiconductor devices. *See* Specification: page 1, lines 18-28.

Semiconductor fabrication processes are among the most sophisticated and complex processes used in manufacturing. In order to perform efficiently, semiconductor fabrication processes require frequent monitoring and careful evaluation. For example, extensive monitoring and evaluation of semiconductor fabrication processes is typically performed to ensure that the processes are within design tolerance and to increase the overall yield of the processes. Ideally, extensive monitoring and evaluation of the processes takes place both during process development and during process control of semiconductor fabrication processes. *See* Specification: page 2, lines 2-15. In addition, as feature sizes of semiconductor devices continue to shrink, a minimum feature size that may be fabricated may often be limited by the performance characteristics of a semiconductor fabrication process. As such, controlling the parameters of processes that may be critical to the resolution capability of a semiconductor fabrication process such as a lithography process is becoming increasingly important to the successful fabrication of semiconductor devices. *See* Specification: page 2, line 17 to page 3, line 2.

There are several disadvantages, however, in using the currently available methods and systems for metrology and/or inspection of specimens fabricated by semiconductor fabrication processes. For example, multiple stand-alone metrology/inspection systems may be used for metrology and/or inspection of specimens fabricated by such processes. As used herein, the term "stand-alone metrology/inspection system" generally refers to a system that is not coupled to a process tool and is operated independently of any other process tools and/or metrology/inspection systems. Multiple metrology/inspection systems occupy a relatively large amount of clean room

space due to the footprints of each of the metrology and/or inspection systems. *See* Specification: page 3, lines 4-17.

In addition, testing time and process delays associated with measuring and/or inspecting a specimen with multiple systems increase the overall cost of manufacturing and the manufacturing time for fabricating a semiconductor device. For example, process tools may often be idle while metrology and/or inspection of a specimen is performed such that the process may be evaluated before additional specimens are processed thereby increasing manufacturing delays. Furthermore, if processing problems cannot be detected before additional wafers have been processed, wafers processed during this time may need to be scrapped, which increases the overall cost of manufacturing. Additionally, buying multiple metrology/inspection systems increases the cost of fabrication. *See* Specification: page 3, lines 19-28.

In an additional example, for in situ metrology and/or inspection using multiple systems, determining a characteristic of a specimen during a process may be difficult if not impossible. For example, measuring and/or inspecting a specimen with multiple systems during a lithography process may introduce a delay time between or after process steps of the process. If the delay time is relatively long, the performance of the resist may be adversely affected, and the overall yield of semiconductor devices may be reduced. As such, there may also be limitations on process enhancement, control, and yield of semiconductor fabrication processes due to the limitations associated with metrology and/or inspection using multiple systems. Process enhancement, control, and yield may also be limited by an increased potential for contamination associated with metrology and/or inspection using multiple systems. In addition, there may be practical limits in using multiple metrology/inspection systems in semiconductor manufacturing processes. In an example, for in situ metrology and/or inspection using multiple systems, integrating the systems into a process tool or a cluster tool may be difficult due to the availability of space within the tool. *See* Specification: page 4, lines 2-18.

The invention as recited in claims 6633-6652 addresses the above-described problems by providing systems configured to determine at least two properties of a specimen. The first

property includes a critical dimension of the specimen. The second property includes a thin film characteristic of the specimen. *See* Specification: page 147, line 15 to page 148, line 3. Therefore, one system can be used to provide substantially more information about a specimen than currently available metrology/inspection systems.

The presently claimed systems and methods provide a number of additional advantages over other systems and methods. For example, the presently claimed systems may be coupled to a process tool. Because the systems may be coupled to a process tool such as a lithography track, properties of a specimen may be determined faster than stand alone metrology and inspection tools. Therefore, a system, as described herein, may reduce the turn-around-time for determining properties of a specimen. A reduced turn-around-time may provide significant advantages for process control. For example, a reduced turn-around-time may provide tighter process control of a semiconductor fabrication process than stand alone metrology and inspection tools. Tighter process control may provide, for instance, a reduced variance in critical dimension distributions of features on a specimen. *See* Specification: page 106, lines 16-24.

ISSUE 1 ARGUMENTS

A. Patentability of Group I Claims 6633, 6636-6637, 6642, and 6645-6647

1. A critical dimension as presently claimed is not equivalent to a critical metric as this term is used in the Specification.

Independent claim 6633 recites in part: "a spectroscopic ellipsometer configured to generate one or more output signals during measurement of the specimen; and a processor coupled to the spectroscopic ellipsometer and configured to determine a critical dimension and a thin film characteristic of the specimen from the one or more output signals."

As defined in the Specification:

> A critical dimension may include a lateral dimension of a feature defined in a direction substantially parallel to an upper surface of the specimen such as width 62 of feature 56

> on specimen 60. Therefore, a critical dimension may be generally defined as the lateral dimension of a feature when viewed in cross section such as a width of a gate or interconnect or a diameter of a hole or via. A critical dimension of a feature may also include a lateral dimension of a feature defined in a direction substantially perpendicular to an upper surface of the specimen such as height 64 of feature 56 on specimen 60. (Specification -- page 74, lines 17-23.)

Therefore, a "critical dimension" as defined in the Specification does not include a thickness of a film. In contrast, the Specification states that "Examples of thin film characteristics include, but are not limited to, a thickness, an index of refraction, and an extinction coefficient." (Specification -- page 250, lines 11-12.) Therefore, a film thickness is defined in the Specification as a thin film characteristic, as presently claimed.

The definition of the term "critical dimension" provided in the Specification is consistent with the accepted meaning of the term known in the art. For example, "critical dimensions (CDs)" are defined as "The widths of lines and spaces of critical circuit patterns as well as the area of contacts" by Peter Van Zant, Microchip Fabrication: A Practical Guide to Semiconductor Processing, Fourth Edition, New York, New York, McGraw-Hill, 2000, p. 598, a copy of which is submitted herewith. In addition, S. Wolf et al., in Silicon Processing for the VLSI Era: Volume 1 - Process Technology, Sunset Beach, California, Lattice Press, 1986, on p. 447, a copy of which is submitted herewith, states that "There are two aspects of feature sizes that must be controlled in the lithographic/etching process: a) the absolute size of a minimum feature, including linewidth, spacing, or contact dimensions (also referred to as a *critical dimension* of CD)." (emphasis in original). In addition, in the Handbook of Silicon Semiconductor Metrology, Alain C. Diebold, New York, New York, Marcel Dekker, Inc., 2001, on p. 377, a copy of which is submitted herewith, M. Cresswell et al. state that "Usually, test patterns include features that have drawn linewidths matching the minimum of the features being printed in the circuit. These linewidths are typically referred to as the process's *critical dimensions* (CDs)." (emphasis in original). Therefore, consistent with the definition of a critical dimension provided in the Specification, the definition of the term critical dimension accepted in the art does not include a thickness of a film. A fundamental principle contained in 35 U.S.C. 112, second paragraph is that applicants are their own lexicographers. They can define in the claims what

they regard as their invention essentially in whatever terms they choose so long as the terms are not used in ways that are contrary to accepted meanings in the art. MPEP 2173.01. It is appropriate to compare the meaning of terms given in technical dictionaries in order to ascertain the accepted meaning of a term in the art. *In re Barr*, 444 F.2d 588, 170 USPQ 330 (CCPA 1971). MPEP 2173.05(a).

The Final Office Action mailed August 24, 2004 (PTO Paper No. 2212004) notes on page 7 that the Specification states:

> critical metrics of a lithography process may include a property such as, but are not limited to, critical dimensions of features formed by the lithography process and overlay misregistration. Critical metrics of a process, however, may also include any of the properties as described herein including, but not limited to, a presence of defects on the specimen, a thin film characteristic of the specimen, a flatness measurement of the specimen, an implant characteristic of the specimen, an adhesion characteristic of the specimen, a concentration of elements in the specimen. (Specification -- page 246, lines 1-8.)

Therefore, the Specification defines the term "critical metric" as a property, two examples of which are a critical dimension and a thin film characteristic, and one example of a thin film characteristic provided in the Specification is a thickness of a film. Consequently, the Specification defines a critical metric as a property, two examples of which are a critical dimension and a film thickness.

However, this definition of a critical metric does not result in a critical dimension being equivalent to a film thickness. For example, a "metric" is commonly defined as "A standard of measurement." *See*, for example, Webster's II New Riverside University Dictionary, Boston, Massachusetts, Houghton Mifflin Company, 1984, p. 748, a copy of which is submitted herewith. As a result, the Specification defines a critical metric or a critical standard of measurement as a property, two examples of which are a critical dimension and a film thickness. Therefore, the term critical metric cannot be interpreted as being equivalent to the term critical dimension such that a critical dimension can be defined as a film thickness as suggested in the Final Office

Action since a "critical dimension" and a "critical metric" are clearly two different terms having different meanings.

For at least the reasons provided above, therefore, the term "critical dimension" is not defined in the Specification as a film thickness. In addition, for at least the reasons provided above, the usual meaning of the term critical dimension accepted in the art is not a film thickness. Therefore, the claimed critical dimension cannot be given a meaning as suggested in the Final Office Action of a film thickness since that meaning of the term critical dimension would be repugnant to (i.e., inconsistent with) its usual meaning. While a term used in the claims may be given a special meaning in the description of the invention, generally no term may be given a meaning repugnant to the usual meaning of the term. *In re Hill*, 161 F.2d 367, 73 USPQ 482 (CCPA 1947). MPEP 2173.05(a).

2. **Aspnes does not teach or suggest a processor coupled to a spectroscopic ellipsometer that is configured to determine a critical dimension of a specimen from one or more output signals generated by the spectroscopic ellipsometer.**

Aspnes discloses a thin film optical measurement system and method with calibrating ellipsometer. Aspnes, however, does not disclose a processor coupled to a spectroscopic ellipsometer that is configured to determine a critical dimension of a specimen from one or more output signals generated by the spectroscopic ellipsometer. For example, Aspnes states that "To determine this information, the processor 48 takes the difference between the sums of the output signals of diametrically opposed quadrants, a value which varies linearly with film thickness for very thin films." (Aspnes -- col. 4, lines 30-34.) Therefore, Aspnes discloses a processor that is configured to determine a film thickness of a specimen. However, Aspnes does not disclose a processor that is configured to determine a critical dimension of the specimen. In addition, as set forth in detail above, the claimed critical dimension is not equivalent to a film thickness. Therefore, Aspnes does not teach or suggest determining a critical dimension as presently claimed. As such, Aspnes does not teach or suggest a processor coupled to a spectroscopic ellipsometer that is configured to determine a critical dimension of a specimen from one or more output signals generated by the spectroscopic ellipsometer.

3. The Examiner has failed to support a ground of anticipation of claim 6633 by Aspnes.

The standard for "anticipation" is one of fairly strict identity. A claim is anticipated only if each and every element as set forth in the claim is found, either expressly or inherently described, in a single prior art reference. *Verdegaal Bros. v. Union Oil Co. Of California*, 2 USPQ2d 1051, 1053 (Fed. Cir. 1987); MPEP 2131. As pointed out above, Aspnes does not teach a processor coupled to a spectroscopic ellipsometer that is configured to determine a critical dimension of a specimen from one or more output signals generated by the spectroscopic ellipsometer, as recited in claim 6633. Aspnes, therefore, does not teach each and every element set forth in claim 6633, and claim 6633 is not anticipated by Aspnes.

Conclusion

As explained in Arguments 1-3 above, certain limitations of independent claim 6633 are not taught or suggested by Aspnes. Claim 6633 is therefore not anticipated by Aspnes. Because claims 6636-6637, 6642, and 6645-6647 are dependent from claim 6633, these claims are also not anticipated by Aspnes. The rejection of Group I claims 6633, 6636-6637, 6642, and 6645-6647 under 35 U.S.C. § 102 is therefore asserted to be erroneous.

B. <u>Patentability of Group III Claim 6635 and 6649-6650</u>

Independent claim 6649 recites: "a spectroscopic ellipsometer configured to generate one or more output signals during measurement of the wafer,...and a processor coupled to the spectroscopic ellipsometer and configured to determine a critical dimension and a thin film characteristic of the wafer from the one or more output signals." Because claim 6649 of Group III recites these limitations, which are similar to those of claim 6633 of Group I, the arguments presented above for patentability of claim 6633 apply equally to claim 6649, and are herein incorporated by reference. Because claim 6635 of Group III is dependent from claim 6633 of Group I, the arguments presented above for patentability of claim 6633 also apply equally to

claim 6635. Claim 6635 further recites that the claimed system is integrated into a process tool. Claim 6649 recites a similar limitation. These additional recitations make claims 6635 and 6649-6650 separately patentable over the cited art, as described in more detail below.

Aspnes does not teach or suggest a system that is configured to determine at least two properties of a specimen and that is integrated into a process tool.

Aspnes states that "The preferred measurement systems rely on non-contact, optical measurement techniques, which can be performed during the semiconductor manufacturing process without damaging the wafer sample." (Aspnes -- col. 1, lines 21-24). Therefore, Aspnes discloses that a measurement system may perform measurements during a process. However, Aspnes does not teach or suggest that a measurement system is or can be integrated into a process tool. For example, measurement systems that are configured to perform measurements after a lithography process but before an etch process may be considered to perform these measurements during a semiconductor manufacturing process. However, such measurement systems are not necessarily integrated into a process tool. Instead, these measurement systems can be configured as stand alone tools or non-integrated tools. Therefore, since Aspnes does not teach or suggest that the measurement system that can perform measurements during a process is integrated into a process tool, Aspnes does not teach or suggest a system that is configured to determine at least two properties of a specimen and that is integrated into a process tool. The claimed system integrated into a process tool is therefore not taught by the cited art, and claims 6635 and 6649 are patentable over this art. Because claim 6650 is dependent from claim 6649, this claim is also not anticipated by Aspnes. Rejection of Group III claims 6635 and 6649-6650 is therefore asserted to be erroneous.

C. <u>Patentability of Group IV Claims 6638-6641</u>

Because claims 6638-6641 of Group IV are dependent from claim 6633 of Group I, the arguments presented above for patentability of claim 6633 apply equally to claims 6638-6641, and are herein incorporated by reference. Claims 6638-6641 further recite that the claimed spectroscopic ellipsometer is configured to illuminate the specimen at a normal angle of

incidence. These additional recitations make claims 6638-6641 separately patentable over the cited art, as described in more detail below.

Aspnes does not teach or suggest a spectroscopic ellipsometer configured to illuminate a specimen at a normal angle of incidence.

Aspnes states that "Broadband spectroscopic ellipsometry (BSE)...(18) includes a polarizer 70, focusing mirror 72, collimating mirror 74, rotating compensator 76, and analyzer 80." (Aspnes -- col. 5, lines 41-46). Aspnes also states that "Mirror 72 focuses the beam onto the sample surface at an oblique angle, ideally on the order of 70 degrees to the normal of the sample surface." (Aspnes -- col. 5, lines 49-52). Therefore, Aspnes discloses a spectroscopic ellipsometer configured to illuminate a specimen at an oblique angle of incidence. However, Aspnes does not teach or suggest a spectroscopic ellipsometer configured to illuminate a specimen at a normal angle of incidence. The claimed spectroscopic ellipsometer is therefore not taught by the cited art, and claims 6638-6641 are patentable over this art. Rejection of Group IV claims 6638-6641 is therefore asserted to be erroneous.

D. <u>Patentability of Group V Claim 6643</u>

Because claim 6643 of Group V is dependent from claim 6633 of Group I, the arguments presented above for patentability of claim 6633 apply equally to claim 6643, and are herein incorporated by reference. Claim 6643 further recites that the claimed processor is configured to use the thin film characteristic to determine the critical dimension. This additional recitation makes claim 6643 separately patentable over the cited art, as described in more detail below.

Aspnes does not teach or suggest a processor that is configured to use a thin film characteristic of a specimen to determine a critical dimension of the specimen.

As discussed further above with respect to the patentability of Group I claims 6633, 6636-6637, 6642, and 6645-6647, Aspnes does not teach or suggest a processor that is configured to determine a critical dimension of a specimen from one or more output signals generated by a spectroscopic ellipsometer. As such, Aspnes cannot teach or suggest a processor configured to

use a thin film characteristic of a specimen to determine a critical dimension of the specimen, since Aspnes does not teach determining a critical dimension at all. The claimed processor is therefore not taught by the cited art, and claim 6643 is patentable over this art. Rejection of Group V claim 6643 is therefore asserted to be erroneous.

E. Patentability of Group VI Claim 6644

Because claim 6644 of Group VI is dependent from claim 6633 of Group I, the arguments presented above for patentability of claim 6633 apply equally to claim 6644, and are herein incorporated by reference. Claim 6644 further recites that the claimed system is coupled to a stand-alone metrology or inspection system and that these systems are configured such that signals may be sent between the systems. This additional recitation makes claim 6644 separately patentable over the cited art, as described in more detail below.

Aspnes does not teach or suggest a system configured to determine at least two properties of a specimen that is coupled to a stand-alone metrology or inspection system.

Aspnes states that "Composite optical measurement system 1 includes a Beam Profile Ellipsometer (BPE) 10, a Beam Profile Reflectometer (BPR) 12, a Broadband Reflective Spectrometer (BRS) 14, a Deep Ultra Violet Reflective Spectrometer (DUV) 16, and a Broadband Spectroscopic Ellipsometer (BSE) 18." (Aspnes -- col. 3, lines 45-50). Therefore, Aspnes discloses one system that includes a number of different measurement devices. However, Aspnes does not disclose that this one system is coupled to a stand-alone metrology or inspection system. Therefore, Aspnes does not teach or suggest a system configured to determine at least two properties of a specimen that is coupled to a stand-alone metrology or inspection system. The claimed system is therefore not taught by the cited art, and claim 6644 is patentable over this art. Rejection of Group VI claim 6644 is therefore asserted to be erroneous.

F. Patentability of Group VII Claim 6648

Because claim 6648 of Group VII is dependent from claim 6633 of Group I, the arguments presented above for patentability of claim 6633 apply equally to claim 6648, and are herein incorporated by reference. Claim 6648 further recites that the claimed specimen includes a substrate suitable for fabrication of a reticle. This additional recitation makes claim 6648 separately patentable over the cited art, as described in more detail below.

Aspnes does not teach or suggest a system configured to determine at least two properties of a substrate suitable for fabrication of a reticle.

Aspnes states that "There is considerable interest in developing systems for accurately measuring the thickness and/or composition of thin films. The need is particularly acute in the semiconductor manufacturing industry where the thickness of these thin film oxide layers on semiconductor substrates is measured." (Aspnes – col. 1, lines 14-18). Therefore, Aspnes discloses measuring properties of a semiconductor substrate. However, Aspnes does not disclose measuring properties of a substrate suitable for fabrication of a reticle such as a glass substrate. Therefore, Aspnes does not teach or suggest a system configured to determine at least two properties of a substrate suitable for fabrication of a reticle. The claimed system is therefore not taught by the cited art, and claim 6648 is patentable over this art. Rejection of Group VII claim 6648 is therefore asserted to be erroneous.

G. Patentability of Group VIII Claim 6651

Because claim 6651 of Group VIII is dependent from claim 6649 of Group III, the arguments presented above for patentability of claim 6649 apply equally to claim 6651, and are herein incorporated by reference. Claim 6651 further recites that the claimed spectroscopic ellipsometer is configured to illuminate the specimen at a normal angle of incidence. This additional recitation makes claim 6651 separately patentable over the cited art, as described in more detail below.

Aspnes does not teach or suggest a spectroscopic ellipsometer configured to illuminate a specimen at a normal angle of incidence.

As discussed further above with respect to the patentability of Group IV claims 6638-6641, Aspnes does not teach or suggest a spectroscopic ellipsometer configured to illuminate a specimen at a normal angle of incidence. The claimed spectroscopic ellipsometer is therefore not taught by the cited art, and claim 6651 is patentable over this art. Rejection of Group VIII claim 6651 is therefore asserted to be erroneous.

ISSUE 2 ARGUMENTS

A. Patentability of Group II Claim 6634

1. A critical dimension as presently claimed is not equivalent to a critical metric as this term is used in the Specification.

Because claim 6634 of Group II is dependent from claim 6633 of Group I, claim 6634 includes all of the limitations of claim 6633. As discussed further above with respect to the patentability of Group I claims 6633, 6636-6637, 6642, and 6645-6647, a critical dimension as presently claimed is not equivalent to a critical metric as this term is used in the Specification. Therefore, the presently claimed critical dimension is not equivalent to a film thickness as suggested in the Final Office Action.

2. Stanke does not teach or suggest a processor coupled to a spectroscopic ellipsometer that is configured to determine a critical dimension of a specimen from one or more output signals generated by the spectroscopic ellipsometer.

Stanke discloses a wafer metrology apparatus and method. Stanke, however, does not disclose a processor coupled to a spectroscopic ellipsometer that is configured to determine a critical dimension of a specimen from one or more output signals generated by the spectroscopic ellipsometer. For example, Stanke states that "Following collection of a reference spectrum a data reduction algorithm utilizing the reference spectrum is used to calculate film thickness from spectra collected from wafer 420." (Stanke -- col. 14, lines 17-20). Therefore, Stanke discloses a

processor that is configured to determine a film thickness of a specimen. However, Stanke does not disclose a processor that is configured to determine a critical dimension of the specimen. In addition, as set forth in detail above, the claimed critical dimension does not include a film thickness. Therefore, Stanke does not teach determining a critical dimension as presently claimed. As such, Stanke does not teach a processor coupled to a spectroscopic ellipsometer that is configured to determine a critical dimension of a specimen from one or more output signals generated by the spectroscopic ellipsometer.

3. The Examiner has failed to support a ground of anticipation of claim 6634 by Stanke.

The standard for "anticipation" is one of fairly strict identity. A claim is anticipated only if each and every element as set forth in the claim is found, either expressly or inherently described, in a single prior art reference. *Verdegaal Bros. v. Union Oil Co. Of California*, 2 USPQ2d 1051, 1053 (Fed. Cir. 1987); MPEP 2131. As pointed out above, Stanke does not teach a processor coupled to a spectroscopic ellipsometer that is configured to determine a critical dimension of a specimen from one or more output signals generated by the spectroscopic ellipsometer, as recited in claim 6633. Stanke, therefore, cannot teach, expressly or inherently, each and every element set forth in claim 6633, and claim 6633 is not anticipated by Stanke.

Conclusion

As explained in Arguments 1-3 above, certain limitations of independent claim 6633 are not taught or suggested by Stanke. Claim 6633 is therefore not anticipated by Stanke. Because claim 6634 is dependent from claim 6633, this claim is also not anticipated by Stanke. The rejection of Group II claim 6634 under 35 U.S.C. § 102 is therefore asserted to be erroneous.

IX. CONCLUSION

For the foregoing reasons, it is submitted that the Examiner's rejection of claims 6633-6651 was erroneous, and reversal of the Examiner's decision is respectfully requested.

The Commissioner is hereby authorized to charge the required fee(s) to deposit account number 50-3268/5589-02326.

Respectfully submitted,

Ann Marie Mewherter

Ann Marie Mewherter
Reg. No. 50,484
Agent for Appellant

Daffer McDaniel LLP
P.O. Box 684908
Austin, TX 78768-4908
Date: 12-13-04

Enclosed herewith:

- Excerpt from Peter Van Zant, Microchip Fabrication: A Practical Guide to Semiconductor Processing, Fourth Edition, New York, New York, McGraw-Hill, 2000, p. 598
- Excerpt from S. Wolf et al., in Silicon Processing for the VLSI Era: Volume 1 - Process Technology, Sunset Beach, California, Lattice Press, 1986, p. 447
- Excerpt from Handbook of Silicon Semiconductor Metrology, Alain C. Diebold, New York, New York, Marcel Dekker, Inc., 2001, p. 377
- Excerpt from Webster's II New Riverside University Dictionary, Boston, Massachusetts, Houghton Mifflin Company, 1984, p. 748

X. APPENDIX

The present claims on appeal are as follows.

6633. A system configured to determine at least two properties of a specimen, comprising:

a spectroscopic ellipsometer configured to generate one or more output signals during measurement of the specimen; and

a processor coupled to the spectroscopic ellipsometer and configured to determine a critical dimension and a thin film characteristic of the specimen from the one or more output signals.

6634. The system of claim 6633, wherein the system is further configured as a stand-alone device.

6635. The system of claim 6633, wherein the system is integrated into a process tool.

6636. The system of claim 6633, wherein the spectroscopic ellipsometer is further configured to illuminate the specimen at an oblique angle of incidence.

6637. The system of claim 6633, wherein the spectroscopic ellipsometer is further configured to illuminate the specimen at an oblique angle of incidence with a light beam comprising visible and ultraviolet light.

6638. The system of claim 6333, wherein the spectroscopic ellipsometer is further configured to illuminate the specimen at a normal angle of incidence.

6639. The system of claim 6633, wherein the spectroscopic ellipsometer is further configured to illuminate the specimen at a normal angle of incidence with linearly polarized light.

6640. The system of claim 6633, wherein the spectroscopic ellipsometer is further configured to illuminate the specimen at a normal angle of incidence with polarized light.

6641. The system of claim 6633, wherein the spectroscopic ellipsometer is further configured to illuminate the specimen at a normal angle of incidence with polarized, visible light.

6642. The system of claim 6633, wherein the spectroscopic ellipsometer is further configured to focus light to a small spot on the specimen.

6643. The system of claim 6633, wherein the processor is further configured to use the thin film characteristic to determine the critical dimension.

6644. The system of claim 6633, wherein the system is coupled to a stand-alone metrology or inspection system, and wherein the systems are configured such that signals may be sent between the systems.

6645. The system of claim 6633, wherein the thin film characteristic comprises optical properties of one or more layers on the specimen.

6646. The system of claim 6633, wherein the critical dimension comprises a lateral dimension of a feature on the specimen defined in a direction substantially parallel to an upper surface of the specimen, a lateral dimension of the feature defined in a direction substantially perpendicular to the upper surface of the specimen, or a sidewall angle of the feature.

6647. The system of claim 6633, wherein the specimen comprises a wafer.

6648. The system of claim 6633, wherein the specimen comprises a substrate suitable for fabrication of a reticle.

6649. A system configured to determine at least two properties of a wafer, comprising:

a spectroscopic ellipsometer configured to generate one or more output signals during measurement of the wafer, wherein the spectroscopic ellipsometer is integrated into a lithography track; and

a processor coupled to the spectroscopic ellipsometer and configured to determine a critical dimension and a thin film characteristic of the wafer from the one or more output signals.

6650. The system of claim 6649, wherein the spectroscopic ellipsometer is further configured to illuminate the specimen at an oblique angle of incidence with a light beam comprising visible and ultraviolet light.

6651. The system of claim 6649, wherein the spectroscopic ellipsometer is further configured to illuminate the specimen at a normal angle of incidence with polarized, visible light.

6652. The system of claim 6649, further comprising a controller computer configured to control a temperature within the track.

circuit board See **printed circuit board.**

circuit layout The calculation of the physical device dimensions required to produce the required electrical parameters. Vertical dimensions determine CVD and doping thickness specifications. Horizontal dimensions determine the wafer pattern dimensions and are the basis for a scaled drawing of the finished circuit (composite drawing).

class number Number of contaminant particles in a cubic foot of air.

clean room An area in which semiconductor device fabrication takes place. The cleanliness of the room is highly controlled in order to limit the number of contaminants to which the semiconductor is exposed.

clear field mask A mask on which the pattern is defined by the opaque areas.

cluster tool Several process stations or tools served by one loading–unloading chamber and wafer-transport system.

CMOS (complementary field-effect transistor) N- and P-channel MOS transistors on the same chip.

collector Along with the emitter and base, one of the three regions of the bipolar type of transistor.

collimated light Light in which the rays are parallel; used for gross visual inspection of surfaces.

composite drawing A scaled drawing of the finished circuit.

conductivity The ability of materials to conduct electricity (measured in siemens for conductance or ohms for resistance).

conductor A material which has low resistivity and high conductivity.

contact The regions of exposed silicon that are covered during the metallization process to provide electrical access to the devices.

contact aligner An aligner tool that clamps the wafer and mask into a tight contact before the resist exposure cycle.

contact mask The step at which holes are put into the wafer layers to allow the metal layer to reach down to the doped silicon substrate.

contamination A general term used to describe unwanted material that adversely affects the physical or electrical characteristics of a semiconductor wafer.

critical dimensions (CDs) The widths of the lines and spaces of critical circuit patterns as well as the area of contacts.

cryogenic pump A vacuum pump that can produce a vacuum to the 10^{-10} torr range, the same level as the vacuum of space. It does not require forepumps or cold traps and is faster than other types of vacuum pumps.

crystal A material in which the atoms are arranged in structured groups called unit cells.

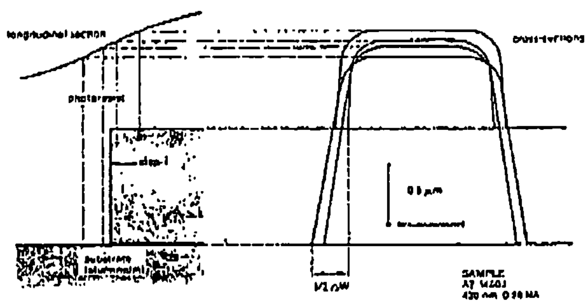

Fig. 32 Longitudinal section and cross sections of a photoresist line running across a one micron aluminum step. The resist profiles are simulated by SAMPLE. The nominal linewidth is 1.8 μm[52]. Reprinted with permission of SPIE.

On some microscopy-based inspection stations, all wafer handling and data processing functions have been automated. Only human vision remains as a non-automated aspect of the inspection procedure. That is, wafers are transported by belts or vacuum shuttle from an input cassette to a pre-aligner, then onto an inspection stage under the microscope (Fig. 31). Automatic handling allows the operator to concentrate on inspection, and to minimize the likelihood of airborne or human handling contamination. Inspection data is entered with a keypad, and many stations include host computer interfacing capabilities for processing and storing the data[63].

In more automated systems, the human operator is completely removed from the *defect inspection task*. That is, *in-process wafer inspection systems*, based on automatic image processing have been introduced. Defect detection is accomplished either by die-to-die or die-to-database comparison. Manufacturers of these systems claim defect detection sensitivities well into the sub-micron range. Such instruments, however, often have difficulty detecting particles on substrates that have surface granularity, or on wafers containing surface topography. In addition, for particles near the minimum-size detection limit, such machines can be prone to miss the presence of some particles, and signal the detection of others that may be non-existent.

The remainder of this section discusses linewidth measurement techniques used to verify that critical dimensions have been produced. In addition, procedures are described for monitoring the variation of linewidths produced in a production environment as a function of time. Such data can serve as a gauge for tracking the performance of a lithographic process line.

Linewidth Variation and Control

There are two aspects of feature sizes that must be controlled in the lithographic /etching process: a) the absolute size of a minimum feature, including linewidth, spacing, or contact dimensions (also referred to as a *critical dimension*, or CD); and b) the variations of the minimum feature sizes as they cross steps on the wafer surface. Linewidth (and spacing) measurements are regularly performed to determine the actual sizes of CDs at each masking level of a process. The variation of linewidths over steps are also monitored, and the causes of the variation were discussed in the section on *Resist Processing: Exposure*. These two aspects are mentioned together because there is also a tradeoff between absolute linewidth size and variation of the size over steps. That is, over-exposure and over-development can improve linewidth control, but at the expense of linewidth size. Figure 32 shows a SAMPLE simulation which calculates linewidth variation, ΔL, across a 0.5 μm step, as the line sizes vary with changing

16
Electrical CD Metrology and Related Reference Materials

Michael W. Cresswell and Richard A. Allen
National Institute of Standards and Technology, Gaithersburg, Maryland

I. INTRODUCTION

In the fabrication of integrated circuits, the steps of depositing a thin film of conducting material, patterning it photolithographically, and then etching it and stripping the remaining resist are repeated several times as required levels are created. On each occasion, the purpose is to pattern a film into a geometry that is consistent with the design of the circuit. The process control mission is to ensure that each respective set of process steps replicates patterning that meets engineering specifications. In most cases, a measure of this compliance is the closeness of the linewidths of features that are produced in the pattern to their intended "design," or "drawn" widths. Ideally, the linewidths of all features on each level would be sampled after the level is patterned, to provide an indication of whether or not the process is under adequate control. However, such a comprehensive metrology operation is neither economically nor technically feasible. Instead, the as-patterned linewidths of a limited selection of features that constitute a "test pattern," are measured. The test pattern is printed at the same time as the circuitry whose fabrication is being monitored, but at a separate location on the substrate that is reserved exclusively for process-control purposes. An example of a commonly used test pattern is shown in Figure 1 (1).

Usually, test patterns include features that have drawn linewidths matching the minimum of the features being printed in the circuit. These linewidths are typically referred to as the process's *critical dimensions* (CDs). It is the widths of the features in the test pattern that are measured by some means to determine if the respective sequence of patterning steps produces results that comply with engineering specifications. The presumption is that, if the CDs of the line features in the test pattern are found to be replicated within predefined limits, the CDs of the features replicated in the synthesis of the integrated circuit are replicated within those limits. The several common linewidth-metrology techniques in use today are electrical CD (ECD) (discussed in this chapter), scanning electron microscopy (SEM) CD, and scanning probe microscopy (SPM) CD.

metr– *pref. var. of* METRO-.
Met·ra·zol (mĕt′rə-zôl′, -zōl′). A trademark for pentylenetetrazol.
me·tre¹ (mē′tər) *n. Chiefly Brit. var. of* METER¹.
me·tre² (mē′tər) *n. Chiefly Brit. var. of* METER².
met·ric¹ (mĕt′rĭk) *adj.* [Fr. *métrique* < *mètre*, meter < Gk. *metron*, measure.] Designating, relating to, or using the metric system.
met·ric² (mĕt′rĭk) *n.* **1.** A standard of measurement. **2.** *Math.* A geometric function defined for a coordinate system such that the distance between any two points in that system may be determined from their coordinates.
met·ric³ (mĕt′rĭk) *n.* [Gk. *metrikē (tekhnē)*, (the art) of meter.] Metrics.
met·ri·cal (mĕt′rĭ-kəl) *adj.* [Lat. *metricus* < Gk. *metrikos* < *metron*, meter.] **1.** Of, relating to, or composed in rhythmic meter. **2.** Of or relating to measurement. **—met′ri·cal·ly** *adv.*
met·ri·ca·tion (mĕt′rĭ-kā′shən) *n.* Conversion to the metric system of weights and measures : METRIFICATION.
metric centner *n.* A unit of mass equal to 100 kilograms.
metric hundredweight *n.* A unit of mass equal to 50 kilograms.
met·rics (mĕt′rĭks) *n.* (*sing. in number*). The branch of prosody dealing with measure and metrical structures.
-metrics *suff.* [< METRICS.] The application of statistics and mathematical analysis to a specified field of study <*econometrics*>
metric system *n.* A decimal system of weights and measures based on the meter as a unit length and the kilogram as a unit mass.
metric ton *n.* A unit of mass equal to 1,000 kilograms.
met·ri·fy (mĕt′rə-fī′) *vt.* & *vi.* **-fied, -fy·ing, -fies.** [OFr. *metrifier* < Med. Lat. *metrificare* : Lat. *metrum*, measure (< Gk. *metron*) + Lat. *facere*, to make.] **1.** To compose in or put into rhythmic meters. **2.** To convert to or adopt the metric system. **—met′ri·fi·ca′tion** *n.*
me·tri·tis (mə-trī′tĭs) *n.* Inflammation of the uterus.
met·ro (mĕt′rō) *n., pl.* **-ros.** [Fr., short for (*chemin de fer*) *métropolitain*, metropolitan (railway).] A subway system.
metro– or **metr–** *pref.* [NLat. < Gk. *mētro-* < *mētra*, uterus < *mētēr*, mother.] Uterus <*metritis*>
me·trol·o·gy (mĕ-trŏl′ə-jē) *n., pl.* **-gies.** [Fr. *métrologie* < Gk. *metrologia*, theory of ratios : *metron*, measure + *logos*, reckoning.] **1.** The science that deals with measurement. **2.** A system of measurement. **—met′ro·log′i·cal** (mĕt′rə-lŏj′ĭ-kəl) *adj.* **—met′ro·log′i·cal·ly** *adv.* **—me·trol′o·gist** *n.*
met·ro·nome (mĕt′rə-nōm′) *n.* [Gk. *metron*, measure + *nomos*, rule.] A device to mark time at a steady beat in adjustable intervals. **—met′ro·nom′ic** (-nŏm′ĭk) *adj.* **—met′ro·nom′i·cal·ly** *adv.*
me·tro·nym·ic (mē′trə-nĭm′ĭk, mĕt′rə-) *also* **ma·tro·nym·ic** (măt′-) *adj.* [Gk. *mētēr*, mother + Gk. *onuma*, name + -IC.] Of, relating to, or derived from the name of one's mother or female ancestor. **—*n.*** A metronymic name.
me·trop·o·lis (mə-trŏp′ə-lĭs) *n.* [LLat. < Gk. *mētropolis*, mother city : *mētēr*, mother + *polis*, city.] **1.** A major city. **2.** A city regarded as the center of a specific activity <a great entertainment *metropolis*> **3.** The chief see of a metropolitan bishop, esp. the main diocese of a specific ecclesiastical province. **4.** The mother city of an ancient Greek colony or state. **5.** *Zool.* A region in which a particular kind of organism lives and thrives.
met·ro·pol·i·tan (mĕt′rə-pŏl′ĭ-tən) *adj.* [ME < LLat. *metropolitanus* < Gk. *mētropolitēs*, citizen of a metropolis < *mētropolis*, mother city. —see METROPOLIS.] **1. a.** Of, relating to, or typical of a metropolis. **b.** Making up a metropolis. **2.** Relating to or comprising the home territory of a sovereign state. **3.** Of or relating to a metropolitan. **—*n.* 1. a.** An archbishop who has authority over bishops in the Roman Catholic and other episcopal churches. **b.** A bishop ranking next below the patriarch who serves as the head of an ecclesiastical province in the Eastern Orthodox Church. **2.** A resident of a metropolis, esp. one who displays big-city attitudes, characteristics, and values.
me·tror·rha·gi·a (mē′trə-rā′jē-ə, -jə) *n.* An abnormal uterine hemorrhage, esp. between menstrual flows. **—me′tror·rhag′ic** *adj.*
-metry *suff.* [ME *-metrie* < OFr. < Lat. *-metria* < Gk. < *metron*, measure.] Process or science of measuring <*isometry*>
met·tle (mĕt′l) *n.* [Alteration of METAL.] **1.** Inherent quality of character and temperament. **2.** Fortitude and courage : SPIRIT. **—on (one's) mettle.** Prepared to put one's spirit or courage to the test.
met·tle·some (mĕt′l-səm) *adj.* Full of courage : HIGH-SPIRITED.
mew¹ (myōō) *n.* [ME < OFr. *mue* < *muer*, to molt < Lat. *mutare*, to change.] **1.** A cage for hawks, esp. when molting. **2.** A secret place : HIDEAWAY. **3. mews.** A small street behind a residential street that contains small apartments. **—*v.* mewed, mew·ing, mews. —*vt.*** To confine in or as if in a cage. **—*vi.*** To molt. —Used of a hawk.
mew² (myōō) *vi.* **mewed, mew·ing, mews.** [ME *mewen*.] To make the high-pitched, crying sound of a cat : MEOW. **—mew** *n.*
mew³ (myōō) *n.* [ME < OE *mǣw*.] A sea bird, *Larus canus*, one of the gulls found in northern Eurasia and western North America.
mewl (myōōl) *vi.* **mewled, mewl·ing, mewls.** [Imit.] To cry weakly.
Mex·i·can (mĕk′sĭ-kən) *adj.* Of or relating to Mexico or to its inhabitants, their language, or their culture. **—*n.*** A native or resident of Mexico.

Mexican hairless *n.* One of a breed of small dogs with a smooth hairless body except for tufts on the head and tail.

Mexican hairless
16–20 inches high at shoulder

Mexican Spanish *n.* The Spanish language as used in Mexico.
me·ze·re·on (mə-zîr′ē-ən) *n.* [ME *mizerion* < Med. Lat. *mezereon* < Ar. *māzaryūn*.] **1.** A native Eurasian shrub, *Daphne mezereum*, having fragrant lilac-purple flowers and small scarlet fruit. **2.** MEZEREUM 2.
me·ze·re·um (mə-zîr′ē-əm) *n.* [Alteration of MEZEREON.] **1.** MEZEREON 1. **2.** The dried bark of certain shrubs of the genus *Daphne*, that was once used externally as a vesicant and internally for arthritis.
me·zu·zah *also* **me·zu·za** (mə-zōō′zə) *n.* [Heb. *mәzūzāh*, doorpost.] A small piece of parchment inscribed with the Biblical passages Deuteronomy 6:4–9 and 11:13–21 and marked with the word "Shaddai," a name of the Almighty, that is rolled up in a container and affixed to a door frame as a sign that a Jewish family lives within.
mez·za·nine (mĕz′ə-nēn′, mĕz′ə-nēn′) *n.* [Fr. < Ital. *mezzanino* < *mezzano*, middle < Lat. *medianus*, in the middle < *medius*, middle.] **1.** A partial story between two main stories of a building. **2.** The lowest balcony in a theater or the first few rows of that balcony.
mez·zo (mĕt′sō, mĕd′zō, mĕz′ō) *n., pl.* **-zos.** A mezzo-soprano.
mezzo for·te (fôr′tā′) *adj.* & *adv.* [Ital.] *Mus.* Moderately loud.
mezzo pi·a·no (pē-ä′nō) *adj.* & *adv.* [Ital.] *Mus.* Moderately soft.
mez·zo-re·lie·vo (mĕt′sō-rĭ-lē′vō, -rĕl-yä′vō, mĕd′-, mĕz′-) *n., pl.* **-vos.** [Ital. *mezzorilievo* : *mezzo*, half (< Lat. *medius*) + *rilievo*, relief < *rilevare*, to raise < Lat. *relevare*, to raise, relieve. —see RELIEVE.] Sculptural relief having modeled forms that project approx. halfway from the background.
mez·zo-so·pra·no (mĕt′sō-sə-prăn′ō, -prä′nō, mĕd′-, mĕz′-) *n., pl.* **-os.** [Ital. : *mezzo*, half (< Lat. *medius*) + *soprano*, soprano. —see SOPRANO.] **1. a.** A voice with a range between soprano and contralto. **b.** A vocal part for a voice with such a range. **2.** A woman with a mezzo-soprano voice.
mez·zo·tint (mĕt′sō-tĭnt′, mĕd′-) *n.* [Ital. *mezzotinto* : *mezzo*, half (< Lat. *medius*) + *tinto*, tint < Lat. *tingere*, to dye.] **1.** A method of engraving a steel or copper plate by burnishing and scraping areas to produce effects of shadow and light. **2.** A print made from a plate engraved by mezzotint.
Mg *symbol for* MAGNESIUM.
mho (mō) *n., pl.* **mhos.** [Backward spelling of OHM.] A unit of conductance reciprocal to the ohm.
mi (mē) *n.* [Med. Lat. —see GAMUT.] *Mus.* The third tone of the diatonic scale in solfeggio.
MIA (ĕm′ī-ā′) *n.* [M(ISSING) I(N) A(CTION).] A serviceman who is reported missing following a combat mission and whose death can be neither confirmed nor denied.
Mi·am·i (mī-ăm′ē, -ăm′ə) *n., pl.* **Miami** or **-is.** A member of an Algonquian tribe of Indians once living in Ohio, Indiana, Illinois, and Wisconsin.
mi·as·ma (mī-ăz′mə, mē-) *n., pl.* **-mas** or **-ma·ta** (-mə-tə) [Gk. < *miainein*, to pollute.] **1. a.** A poisonous atmosphere once believed to rise from swamps and putrid matter and cause disease. **b.** A thick vaporous atmosphere or emanation <a *miasma* of cigar smoke> **2.** A harmful influence or atmosphere <a *miasma* of evil> **—mi·as′mal, mi′as·mat′ic** (-măt′ĭk), **mi·as′mic** (-mĭk) *adj.*
mi·ca (mī′kə) *n.* [NLat. < Lat., grain.] Any of a group of chemically and physically related mineral silicates, common in igneous and metamorphic rocks, that contain hydroxyl, alkali, and aluminum silicate groups and can be split into flexible sheets used in insulation. **—mi·ca′ceous** (-kā′shəs) *adj.*
Mi·cah (mī′kə) *n.* [Heb. *Mīkhāh*.] —See table at BIBLE.
mice (mīs) *n. pl. of* MOUSE.
mi·celle (mĭ-sĕl′) *n.* [NLat. *micella* < Lat. *mica*, grain.] **1.** A submicroscopic aggregation of molecules, as a droplet in a colloidal system. **2.** A colloidal organic particle found in coal. **3.** A coherent strand or structure in synthetic or natural fibers. **4.** A submicroscopic structural unit of protoplasm. **—mi·cel′lar** (mĭ-sĕl′ər) *adj.*